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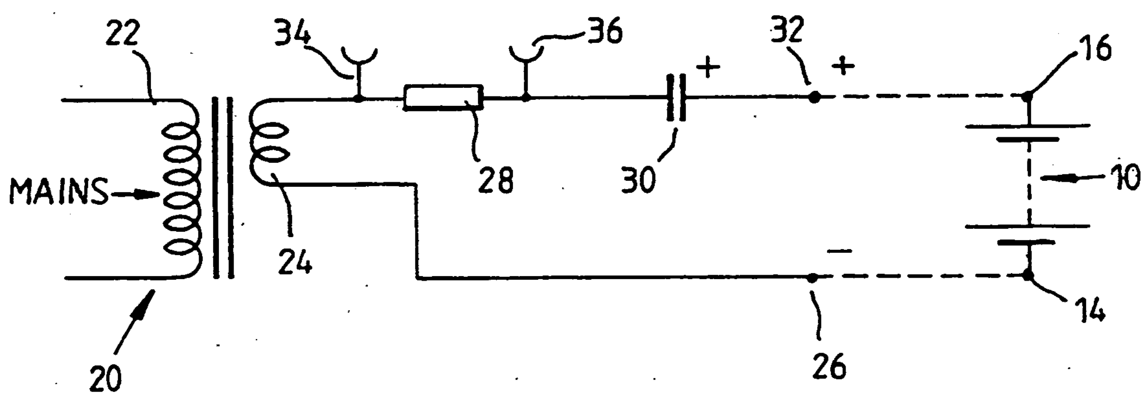

(57) Abstract

A method of testing a battery having a plurality of series cells comprises applying a mains-frequency AC test voltage across the battery (10) from a transformer (20) to generate an AC current therein without drawing a DC current from the battery, measuring the impedance of at least one cell of the battery (or a quantity related thereto) and utilising the impedance or the related quantity as an indication of the condition of the at least one cell. The related quantity may be an AC voltage across the cell. DC drain is prevented by a blocking capacitor (30).

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A Method and Apparatus for Battery Testing.

This invention relates to a method and apparatus for testing the condition of a battery having a plurality of cells in series.

It is common in various systems such as for example a mainframe computer installation to provide a back-up power supply in the form of a storage (e.g. lead-acid) battery which automatically is switched-in in the event of a mains power supply failure.

At regular intervals such batteries must be tested to ensure that they are in good condition and will perform if required.

The conventional method for checking such batteries, which may comprise two hundred or more individual cells, is to perform a discharge test in which the battery is connected to a load bank of relatively low resistance but high power-dissipation capacity. The heavy discharge current produced by the battery in such a test is a general indication of the overall condition of the battery, but does not reveal the condition of each cell, the failure of any one of which may disable the battery. Furthermore considerable preparatory work is necessary to bring the load-bank on-site and to connect it to the battery. In addition the test generates considerable heat and the battery requires recharging after the test.

An object of the present invention is to provide a method and apparatus for testing multi-cell batteries in which the inconvenience and expense of a discharge test is avoided. Another object is to provide a method and apparatus with which it is possible to obtain an indication of the condition of each individual cell of the battery.

Thus, in one aspect the invention provides applying a mains-frequency AC test voltage across the battery to generate an AC current therein without drawing a DC current from the battery, measuring individually the impedance of at least one cell (as hereinafter defined) of the battery (or a quantity related thereto) and utilising the impedance or the related quantity as an indication of the condition of the at least one cell.

In another aspect the invention provides apparatus for use in the aforesaid method comprising means for deriving from an AC mains supply an AC test voltage of the same frequency, means for applying the test voltage to the battery to generate an AC current therein without drawing a DC current from the battery and means for measuring the impedance of the cell or a quantity related thereto.

Some large standby batteries have individual cells arranged in blocks eg. of six cells which are constructed in an integral case in the manner of a motor car battery. There is no access to the interconnections between the cells in each block, and so they cannot be tested individually. However a large battery will comprise a considerable number of such blocks, perhaps twenty, thirty or more, and many of the benefits of the present invention will be achieved by testing each block of cells in the same way as contemplated for individual cells. Therefore the term "cell" as used herein includes a block of cells when forming a storage or standby battery with other such blocks, especially a large number thereof.

The AC voltage across the at least one cell may be the related quantity.

The voltage may be compared with a corresponding voltage across at least one other cell to indicate the condition of the at least one cell.

The AC current through the battery may be measured to provide with the AC voltage across the at least one cell a measure of the impedance thereof as an indication of the condition of the at least one cell.

Preferably the AC current is measured by measuring an AC voltage across a resistance by means of the same voltmeter as is used for measuring the AC voltage across the at least one cell.

The means for deriving the AC test voltage may comprise a transformer.

A blocking capacitor may be employed to prevent a DC current being drawn from the battery. There may be a plurality of blocking capacitors, at least one of which may be switched into or out of the circuit.

The method may comprise measuring the impedance or said quantity related thereto for each cell of the battery, and comparing said measurements to determine the relative conditions of the cells.

Alternatively, the method may comprise comparing the impedance of the cell or the quantity related thereto with the value thereof measured on a previous occasion to detect a change in the condition of the cell.

Thus, the apparatus may include means for recording and comparing the measurements.

As stated, the method is particularly applicable to the testing of back-up power supply batteries at their installed locations.

The invention will now be described with reference to the

accompanying drawings, wherein

Figure 1 shows diagrammatically one embodiment of the invention;

Figure 2 shows a modification to the embodiment of Figure 1;

Figure 3 shows a further embodiment of the invention; and

Figure 4 shows typical results obtainable from the Figure 3 embodiment.

A standby battery 10 comprises a large number, perhaps more than two hundred, individual cells in series, and has external terminals 14, 16, the DC potential across which may be up to 450v.

Apparatus according to the invention comprises a transformer 20, the primary winding 22 of which in operation is connected to the AC mains supply.

The secondary winding 24 is connected at one end to a terminal 26. At the other end it is connected via a resistor 28 and DC blocking capacitor 30 to another terminal 32. Measurement points 34,36 are provided at each end of the resistor 28 so that the AC current through it may be measured by applying voltmeter to measure the AC voltage drop across it.

In operation the terminals 26,32 are respectively connected to the battery terminals 14,16 to apply a mains frequency AC voltage. The DC blocking capacitor 30 prevents discharge of the battery through the transformer secondary 24.

The AC current through the resistor is measured indirectly by means of a voltmeter applied at 34,36. This same voltmeter is then used to measure the AC voltage across each cell of the battery. The AC voltage divided by the AC current indicates the nominal impedance of the cell; at mains frequency (50/60Hz) quadrature components of the impedance are

negligible and the impedance is for all practical purposes resistive.

The impedance of the cells may then be compared, whereby any cells with impedance different from the norm are identified and may be checked for incipient failure.

The impedance of each cell may also be compared its value measured on a previous occasion, and any deteriorating trend identified in good time for remedial action.

The apparatus may be used over a wide range of cell sizes, which may vary in impedance from fraction of a milliohm to approaching one hundred milliohms. The blocking capacitor 30 represents the major component of the total impedance of the series circuit consisting of the capacitor and the battery, and consequently effectively controls the current in the circuit. The current typically is chosen to be in the range of about one amp to several amps, depending on the size of the battery, to give a convenient voltage reading without causing significant heating of the cells during the test. Small-capacity batteries (e.g. a few amp hours) have a lower thermal capacity than large ones and thus for them a test current at the lower end of the range is preferred.

The capacitor 30 may usefully be constituted by two or more switchable capacitors which can be individually switched into or out of the circuit to provide a range-change facility enabling the current to be chosen appropriately for the particular test e.g. so that it is approximately the same as in an previous test of the same battery.

The method may be simplified, provided the current through the battery is kept constant. Then as between individual cells, or

(subject to metering accuracy) between successive tests of the same cell on different occasions, the AC voltage across the cell is proportional to impedance and may be interpreted as indicative of the condition of the cell.

The apparatus usefully may be packaged such that the voltmeter (40, Fig.2) may be switched between the measurement points 34,36 and a pair of wander probes 42,44 used for testing each cell of the battery as already described. The switching is shown symbolically as achieved by a double-pole double-terminal mechanical switch 46, but other more elegant arrangements can readily be envisaged.

For example, if a digital voltmeter is employed then the incorporation of simple logic circuitry would enable an automated test routine to be adopted, in which following the application of the probes to each cell the voltage is measured, then the current is measured automatically, the impedance calculated and displayed on a VDU (e.g. a LCD) and/or stored in a memory, in which case a comparison with a previous reading could also be displayed. Additionally a hard-copy print-out could be provided e.g. for retention by the operator of the system.

It will be appreciated that the invention permits the battery to be tested in-situ and without disconnection of the cell-to-cell interconnections of the battery, enabling testing to be performed in inaccessible locations.

An example of a digital sysem is shown in Figure 3, in which those features already described have the same reference numerals as in Figures 1 and 2, and the circuit of Figure 2 is shown generally at 50.

The system is intended for testing storage battery strings having a terminal voltage of up to 450v DC. The battery blocks or groups making up the string are usually mounted on trays which are housed in cabinets or racks up to 2.5 metres high and three batteries deep. Working on these installations requires the technician carrying out the task to pay attention to the risk of electric shock while probing the batteries. Furthermore, it is tedious and conducive to error for the technician to measure each battery and then put down the test probes in order manually to record the test values, especially since there can be up to 600 results for each string. Moreover, he then has to interpret the result for each cell to decide if further action is needed.

Frequently there is no convenient place to support the voltmeter so that the display can be easily read. This can be particularly difficult when probing the batteries at the rear of the cabinet, and at the same time ensuring contact with dangerous voltage points is avoided.

To meet these operational difficulties, firstly the probes 42,44 are made long enough to enable the terminals of individual cells or blocks to be probed without the technician having to lean over batteries in front of those under test. Secondly, the voltmeter 40 is a remotely programmable dual input digital multimeter which is interfaced with a small personal computer 52 of the "organiser" type. The voltmeter 40 is housed in a shoulder bag and the organiser is belt-mounted so that the technician has freedom of movement and may concentrate on the task of probing the cells.

The organiser 52 is programmed with menu-selection software to enable the technician to specify the parameter to be measured. In

addition to measuring the a.c. current and voltage drop to determine the impedance of the cell, the system can measure the d.c. float voltage (the voltage across the cell whilst on-charge) and the open-circuit voltage. The organiser also stores previous measurements for each cell, and each time the cell is tested the latest results are compared and the memory updated.

The software includes upper and lower test limits for each variable, which limits are updated as a database of past test results for each individual cell and for types of cell is built up.

Once a given menu is selected, on probing a cell, the software detects a cell variable and automatically selects the appropriate range on the programmable voltmeter. The voltmeter then feeds back to the organiser the measured values in digital form. The software compares the digital values with the set values and detects a stable reading to store.

The organiser is set to give an audible signal (bleep) from its internal loudspeaker 54 when each variable has been measured, compared and stored, thereby informing the technician that the test is complete for that cell. A continuous signal is sounded when an out-of-limit value is detected, alerting the technician to check connections, etc. and to repeat the test to establish whether the cell is indeed faulty, or whether the alert was due to a probing error.

Thus the technician may perform the tests relying only on audible signals, and the need to record the results manually is avoided together with the need repeatedly to observe the multimeter display.

The software further permits the technician to key-in other

relevant service information, such as user comments or the technician's observations on the physical condition of the cells.

All the data is stored in the organiser in a removable RAM pack which is passed back to the service base to permit a detailed report to be formulated in another software package running on a desk-top personal computer.

Figure 4 illustrates the manner in which the impedances may be displayed graphically for a large storage battery having thirty-three battery blocks of six cells each. There is clearly a problem with blocks numbers 3 and 4, and a number of other blocks, eg. numbers 15 and 31 also give cause for concern.

Claims

1. A method of testing a battery having a multiplicity of series cells comprising deriving a mains-frequency AC test voltage from a mains supply, applying said test voltage across the battery to generate an AC current therein without drawing a DC current from the battery, measuring individually the impedance of at least one of the cells (as hereinbefore defined) of the battery (or a quantity related thereto) and utilising the impedance or the related quantity as an indication of the condition of the at least one cell.

2. A method as claimed in Claim 1, wherein the AC voltage across the at least one cell is the related quantity.

3. A method as claimed in Claim 2, wherein the voltage is compared with a corresponding voltage across at least one other cell to indicate the condition of the at least one cell.

4. A method as claimed in Claim 2 or Claim 3, wherein the AC current through the battery is measured whereby to provide with the AC voltage across the at least one cell a measure of the impedance thereof as an indication of the condition of the at least one cell.

5. A method as claimed in Claim 4, wherein the AC current is measured by measuring an AC voltage across a resistance by means of the

same voltmeter as is used for measuring the AC voltage across the at least one cell.

6. A method as claimed in any preceding claim comprising measuring the impedance or said quantity related thereto for each cell of the battery, and comparing said measurements to determine the relative conditions of the cells.

7. A method as claimed in any of Claims 1 to 5, comprising comparing the impedance of the cell or the quantity related thereto with the value thereof measured on a previous occasion to detect a change in the condition of the cell.

8. A method as claimed in any preceding claim, wherein the battery is a back-up power supply and is tested at its installed location.

9. Apparatus for use in the method of Claim 1, comprising means for deriving from an AC mains supply an AC test voltage of the same frequency, means for applying the test voltage across the battery to generate an AC current therein without drawing a DC current from the battery and means for measuring individually the impedance of at least one of the cells of the battery or a quantity related thereto, and means for indicating the value of said impedance or related quality.

10. Apparatus as claimed in Claim 9, wherein the means for deriving the AC test voltage comprises a transformer.

11. Apparatus as claimed in Claim 9 or 10, comprising a blocking capacitor to prevent a DC current being drawn from the battery.

12. Apparatus as claimed in Claim 11, wherein there are a plurality of blocking capacitors, at least one of which may be switched into or out of the circuit.

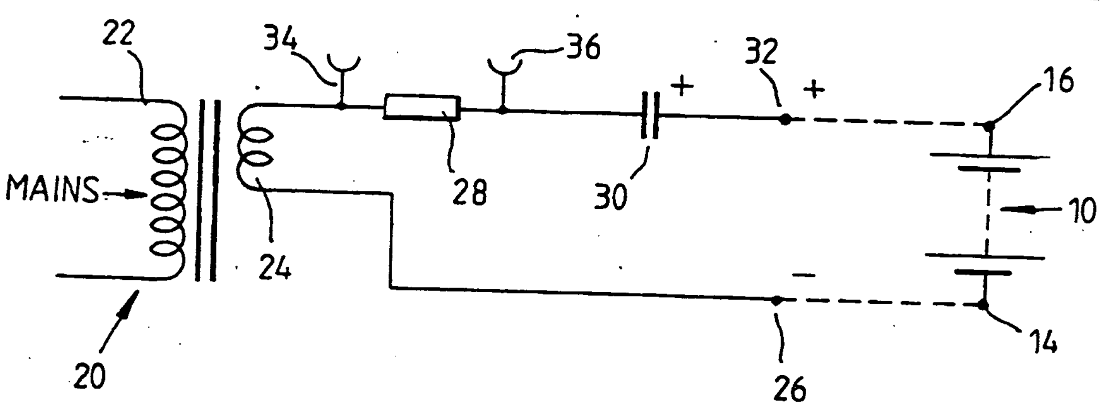
13. Apparatus as claimed in any of Claims 9 to 12, comprising means for measuring the AC current through the battery.

14. Apparatus as claimed in Claim 13, wherein the means for measuring the AC current comprises a resistive element and means for connecting a voltmeter to measure the AC voltage across the resistive element said voltmeter also being connectable to measure the AC voltage across the at least one cell.

15. Apparatus as claimed in any of Claims 9 to 14, for use in the method of Claim 6, comprising means for recording and comparing the impedance or related quantity measured for each cell with that for the other cells or for the same cell measured on a previous occasion, and for indicating the result of said comparison.

16. A method of or apparatus for testing a battery substantially as herein described with reference to the accompanying drawings.

Fig.1



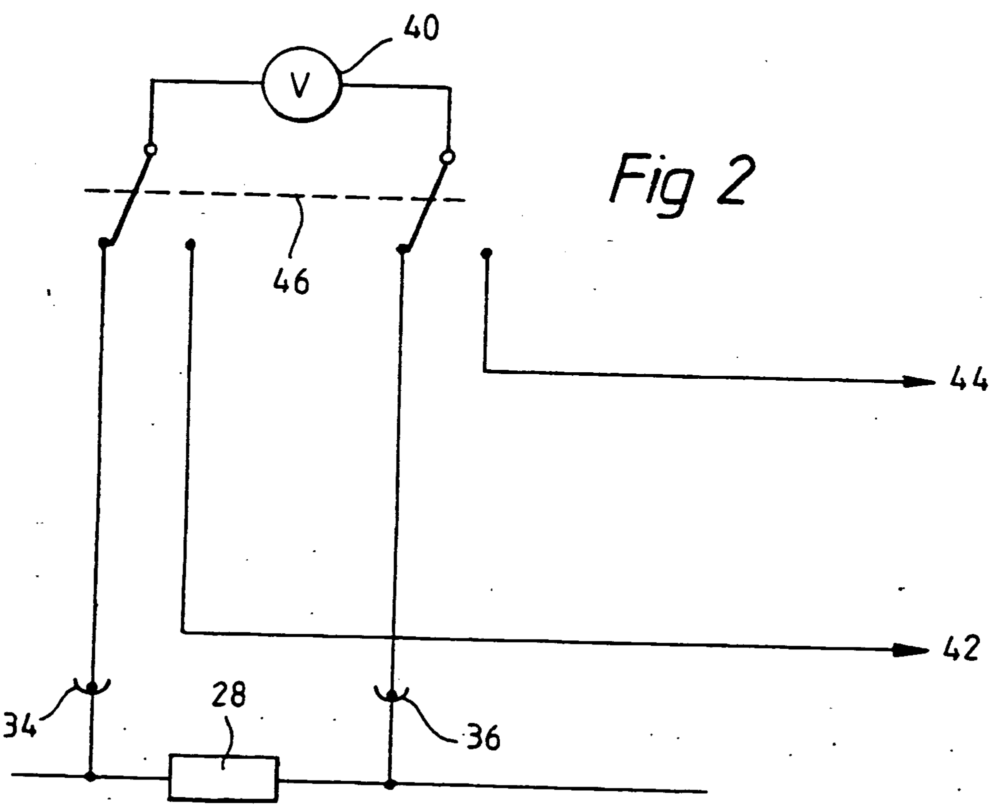


Fig 2

Fig. 3

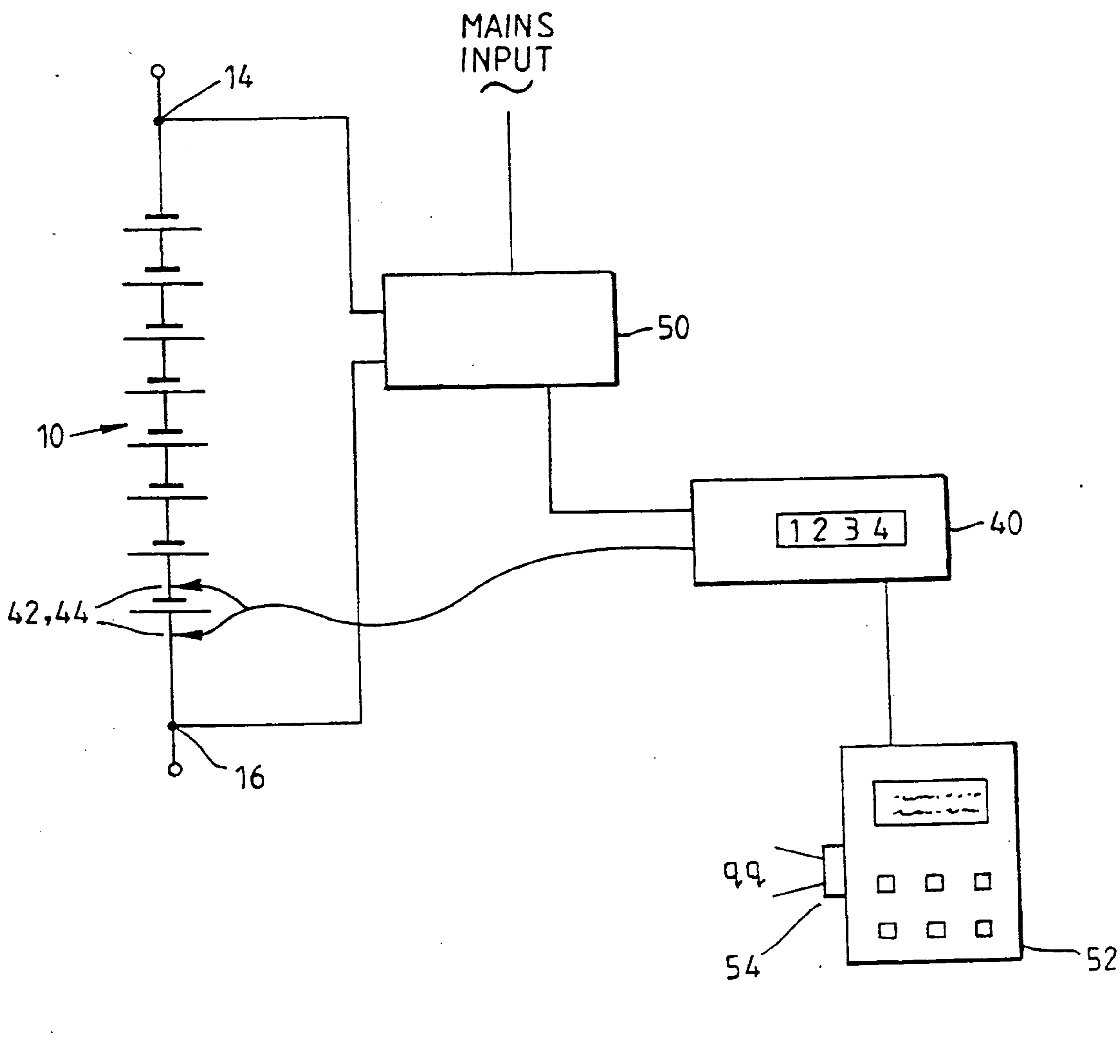
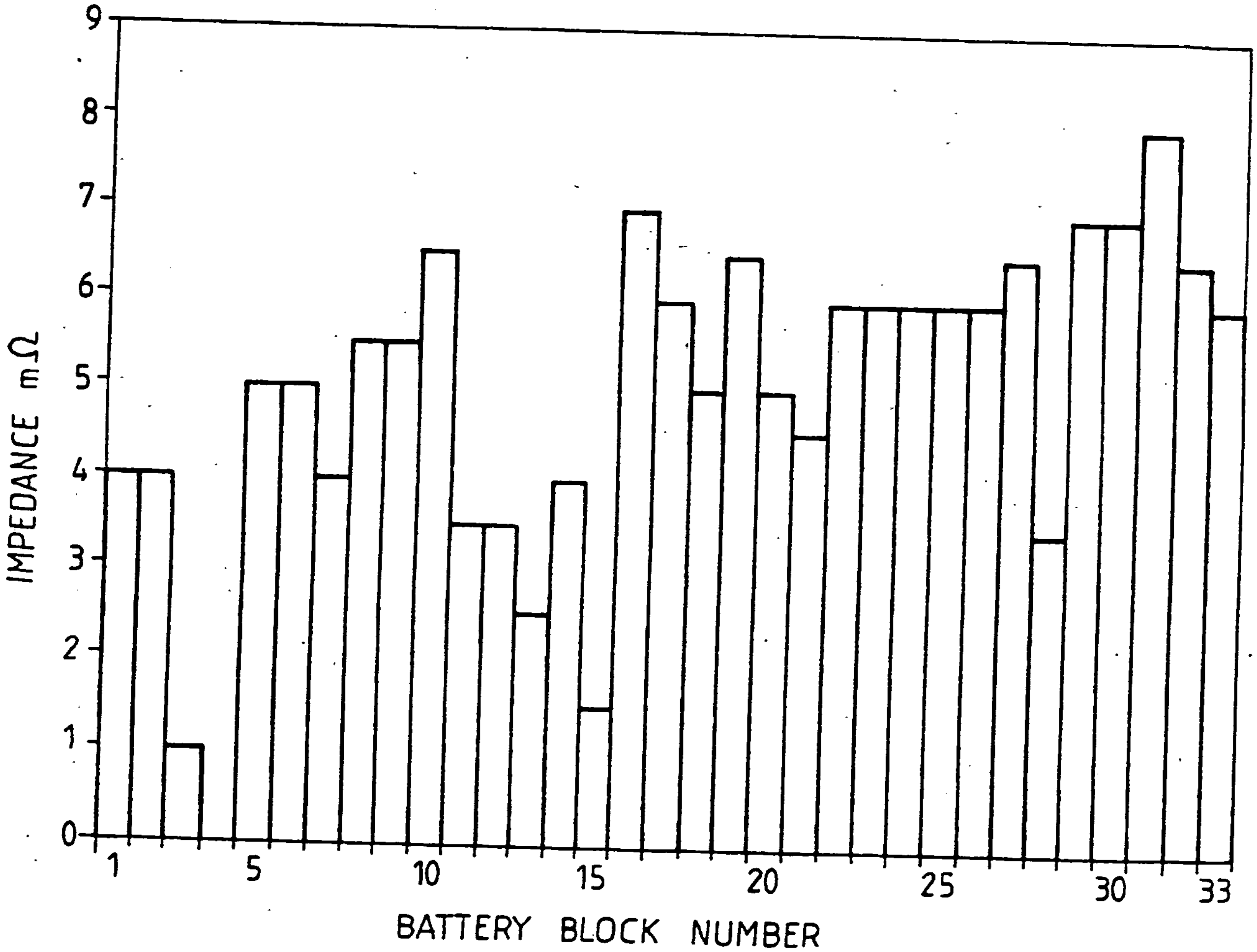


Fig.4


9
8
7
6
5
4
3
2
1
0
IMPEDANCE mΩ
1
5
10
15
20
25
30
33
BATTERY BLOCK NUMBER

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 93/01105

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 G01R31/36

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	G01R

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
Y	US,A,3 234 538 (PARKE) 8 February 1966 see column 1, line 9 - line 60 see column 2, line 44 - column 3, line 3 see column 3, line 54 - column 4, line 9; figures 1,3,4 ---	1,2,4,6, 8-11,13, 16
Y	WO,A,8 801 055 (COMMONWEALTH EDISON) 11 February 1988 see page 9, line 27 - page 11, line 22 see page 13, line 10 - page 14, line 28; figures 1,2 ---	1,2,4,6, 8-11,13, 16
A	DE,A,1 938 076 (BROWN, BOVERI) 4 February 1971 see page 5, paragraph 2 - page 6, paragraph 1; figure 1 ---	1-16

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IV. CERTIFICATION

2

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
23 AUGUST 1993	03.09.93
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	IWANSSON K.G.

International Application No PCT/GB 93/01105

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	US,A,3 753 094 (FURUISHI) 14 August 1973 -----	

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

GB 9301105
SA 74606

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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
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		DE-A-	3773645	14-11-91
		EP-A,B	0276305	03-08-88
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		FR-A-	2055586	07-05-71
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US-A-3753094	14-08-73	None		

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